Deciphering the effect of propionic acid on anaerobic digestion of sludge: gas production and microbial community structure

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Introduction

Many governments of European Union encourage circular bioeconomy. That is why anaerobic digestion (AD) represents one of the most common ways to treat sewage sludge. AD can, at the time, reduce amounts of this waste and valorize its organic matter by producing biogas (mainly CO_2 and CH_4), a renewable energy source.

This bioconversion process is catalyzed by highly diverse microbial communities (Figure 1), whose growth and activity are influenced by various biotic and abiotic factors. Among abiotic factors, intermediate compounds of AD, namely, volatile fatty acids, inhibit AD itself. The understanding of this inhibition and the microbial targets remained to be solved.

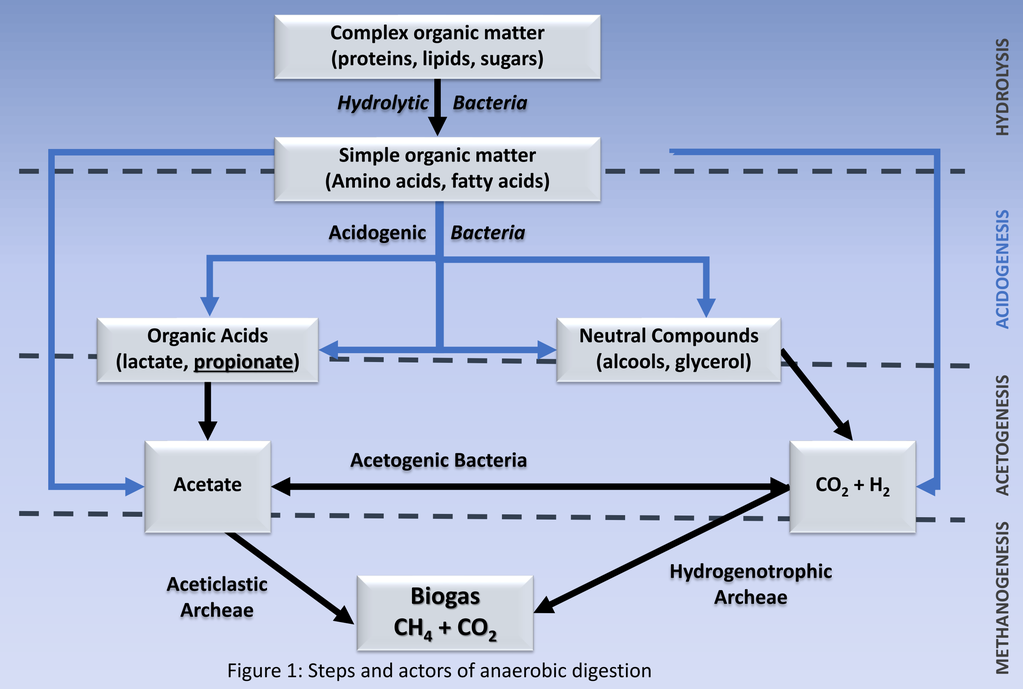


Figure 1: Steps and actors of anaerobic digestion

Aim: Measure the effects of propionic acid on both the gas production and the microbial community structure, in order to identify potential microbial biomarkers of inhibition.

Material and Methods

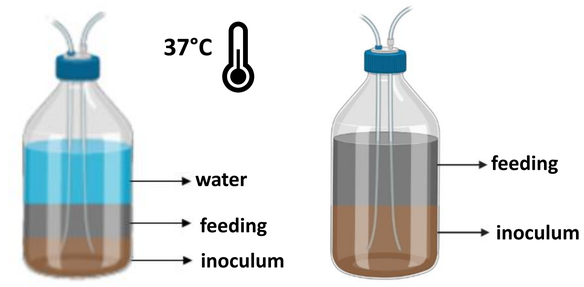
1. Experimental design:

Biochemical methane potential (BMP) test: AMPTS II (Automatic Methane Potential Test System II, Bioprocess, Lund, Sweden)

Amendment at the beginning of the incubation:
- propionic acid (HPr)
- sodium propionate (NaPr)
- sodium chloride (NaCl)
- **or** hydrochloric acid (HCl)

1st experiment kinetics (x15 pilots)

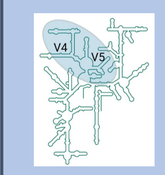
2nd experiment propionate or acidification? (x30 pilots)



- Feeding: mixed sewage sludge
- Inoculum: mesophilic digested sewage sludge

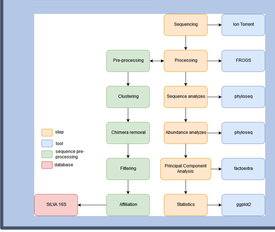
2. Microbial diversity analysis

DNA extracted from digestate (NucleoBond® RNA Soil kit and its DNA co-elution set (Macherey Nagel)



PCR of V4-V5 hypervariable regions of the *16S rRNA* gene of bacteria and archaea

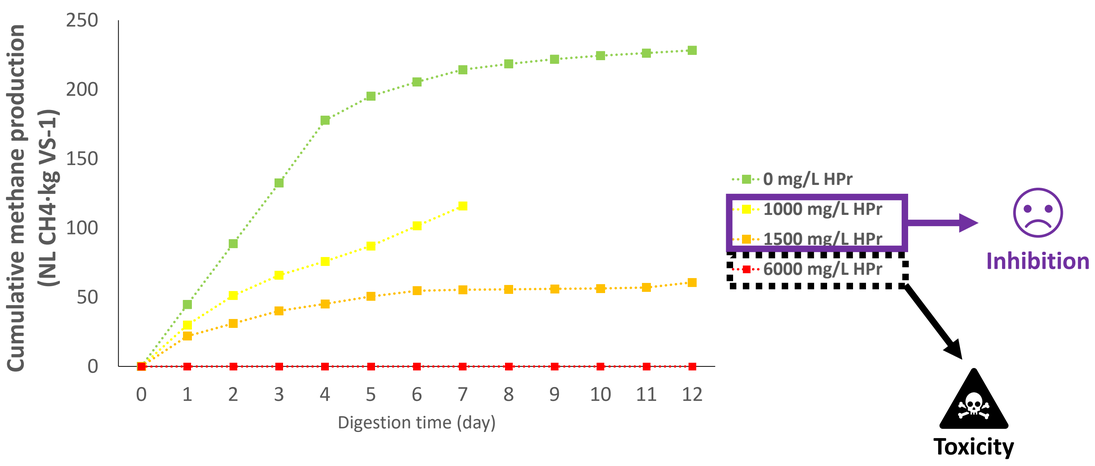
Sequencing with Ion torrent PGM technology (Life Technologies, Carlsbad, US)

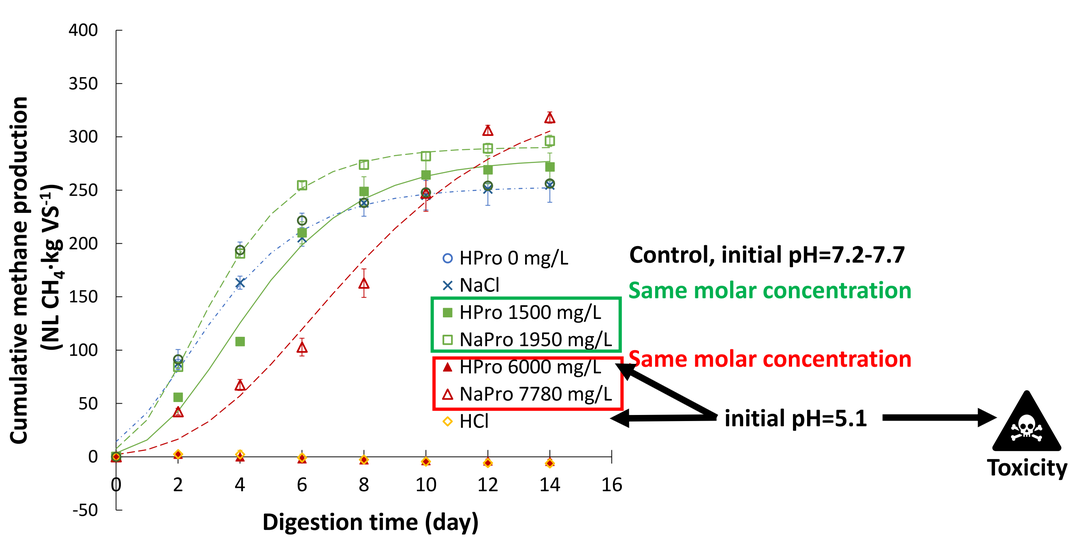


V4 regions reads analysis with function "Galaxy" on the "INRAE Migale11 bioinformatics platform servers", using the FROGS pipeline (Escudié et al. bioinformatics, 34, 2018)

Results

GAS PRODUCTION

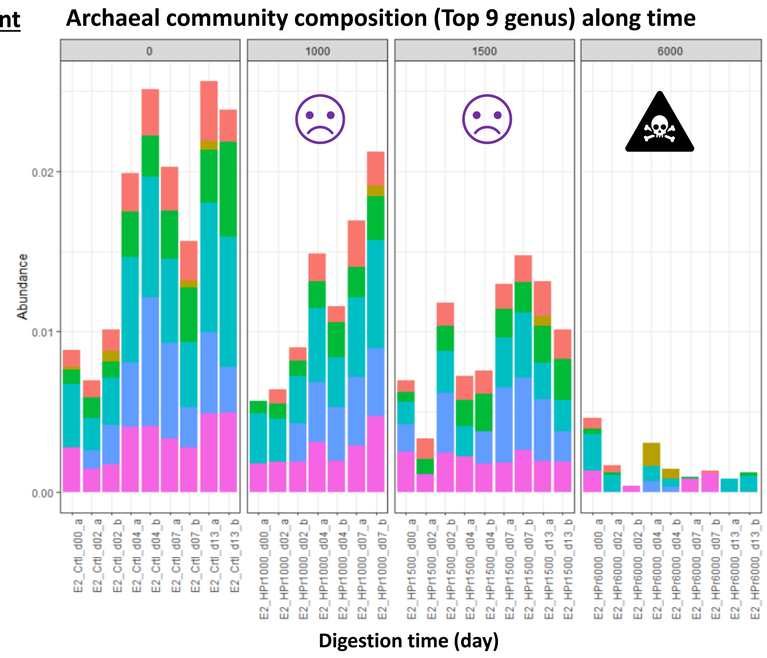




MICROBIAL COMMUNITY

1st experiment kinetics (x15 pilots)

Archaeal community composition (Top 9 genus) along time

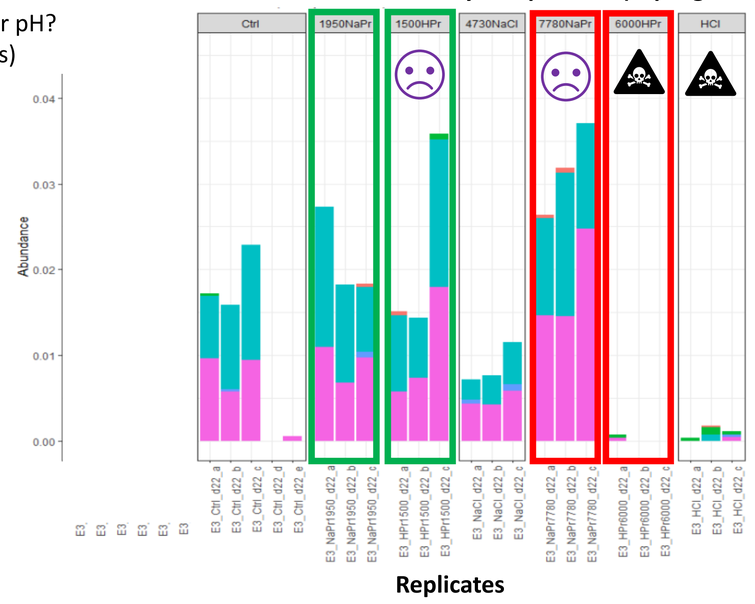


Mean number of reads per sample: 34,000

- **Decrease of archeal abundance with [HPr]**
- **Resilience of the community except at 6,000 mg/L**

2nd experiment propionate or pH? (x30 pilots)

Final archaeal community composition (Top 9 genus)



Mean number of reads per sample: 30,700

- **Decrease of archeal abundance with acidification and not with [HPr]**

Conclusions

The observed stop of CH_4 production was likely due to the pH decrease caused by the dissociation of the propionic acid and entailing the devastation of the archaeal community. When a transient inhibition occurred, different archaea became dominant.

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